Hydrogeological Investigation
112 Montreal Road, Ottawa, Ontario

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1 Introduction

1.1 Project Description

EXP Services Inc. (EXP) was retained by 2705460 Ontario Inc. to prepare a hydrogeological assessment report for the proposed development at 112 Montreal Road, Ottawa, Ontario site.

The subject site is just west of the Vanier Parkway, as shown on Figure No. 1. The terms and conditions of this assignment were outlined in EXP Services Inc. (EXP) proposal number: OTT-00214936-C0 dated June 17, 2022. Drawing SP-2 titled "Site Plan Overall" by Roderick Lahey Architects Ltd. (rla), Revision 6, dated March 15, 2023, was provided. The drawing indicates that the proposed development will be phased with Phase I including the construction of an eight (8) storey mixed use building (Building A) and a thirty-seven (37) storey residential apartment building (Tower B1). It is understood that the finished floor elevations of Building A will be 56.78 m and the finished floor elevation of Building B1 will be 57.47 m. Phase II of the development includes the construction of a twenty-eight (28) storey (Tower B2) and a sixteen (16) storey (Tower B3) residential building. Finished floor elevations of the Phase II buildings have not been provided. It is understood that underside of footing elevation for the buildings will be at Elevation 44.0 m.

EXP conducted a Phase One ESA and a Phase Two ESA at the site in 2014, which was updated in 2023, that included the additional parcel of land to the south. The pertinent information gathered from those investigations is utilized for this report.

1.2 Project Objectives

The main objectives of the hydrogeological assessment are as follows:

- Establish the local hydrogeological settings for this Site;
- Provide Preliminary recommendations on short-term during construction and long-term foundation drainage dewatering pumping rates;
- Assess groundwater quality; and
- Prepare a hydrogeological assessment report with recommendations for dewatering pumping, discharge management and impact assessment from the proposed construction.

1.3 Scope of Work

To achieve the investigation objectives, EXP has completed the following scope of work:

- Reviewed available geological and hydrogeological information for the Site;
- Conducted Single Well Response Tests (SWRT) on three (3) monitoring wells to assess hydraulic conductivities of the bedrock at the Site;
- Completed two (2) rounds of groundwater level measurements;
- Collected one (1) groundwater sample for analyses of parameters, as listed in the City of Ottawa Sanitary and Storm Sewer Use By-Law;
- Evaluated the information collected during the field investigation program, including borehole geological information, Water Well Records (WWR), SWRT results, groundwater level measurements and groundwater water quality;
- Prepared site plans, cross sections, geological mapping and groundwater contour mapping for the Site;
- Provided preliminary recommendations on the requirements for construction and long-term dewatering;

- Provided recommendations on the Ministry of Environment, Conservation and Parks (MECP) Water Taking Permits and City of Ottawa Sewer Discharge Agreements (SDA) for the construction and post-construction phases; and
- Prepare a hydrogeological assessment report in support of a permit (EASR or a Category 3 PTTW) from the Ministry of Environment, Conservation and Parks.

The hydrogeological assessment for this site was prepared in accordance with the Ontario Water Resources Act, Ontario Regulation 387/04, and City of Ottawa Sewer Use Bylaw. The scope of work outlined above was made to assess dewatering and included a review of Environmental Site Assessments (ESA).

1.4 Review of Previous Reports

The following reports were reviewed as part of this 112 Montreal Road, Ottawa, Ontario:

1. Phase I and II Environmental Site Assessment, Butler Hotel, Vanier, Ontario, dated January 10, 1995, prepared for Gowling Strathy and Henderson, Suite 4900, Commerce Court West, Toronto Ontario M5L 1J3, prepared by Trow Consulting Engineers Ltd.
   - A Phase I ESA identified the following potential contaminant sources: Esso Gas Station to the northeast, an above ground storage tank located on the adjacent property on the southwest corner and an underground fuel oil tank located in the crawl space of the building along the Vanier Parkway, and oil stains and unidentified black substances were noticed in the crawl space under the floor of Room 156.
   - A Phase II ESA was then undertaken and completed in two (2) stages - sixteen (16) boreholes and eight (8) test pits were completed in Stage 1 and additional nine (9) boreholes were drilled in Stage 2. Monitoring wells (MW) were installed at six (6) borehole locations. Soil and groundwater samples were collected and analyzed for metals, organic and other potential contaminants. Surface soils at one location were contaminated with total petroleum hydrocarbons (TPHs) above MECP Level II criteria. Initial testing of groundwater samples (April and June of 1994) indicated that one location had detectable concentrations of benzene, toluene, ethylene and xylene (BTEX) and TPH above the MOEE Ontario Drinking Water Quality Objectives (ODWQO). However later sampling (November 1994) and analysis of groundwater sample from the same monitoring well indicated that the concentrations of BTEX and TPH parameters decreased below the provincial criteria.
2. Phase I Environmental Site Assessment Update, 112 Montreal Road, Ottawa, Ontario, prepared for 1147310 Ontario Incorporated, dated November 2010 prepared by Trow Associates Inc. (now EXP).
   - The Phase I ESA was completed to update previously completed Phase I ESA study. A Phase II ESA was not recommended. This update was completed to identify new actual or new potential site contamination beyond the contamination identified by TROW in Phase I ESA completed in 1994, Phase II ESA completed in 1995, a Phase I ESA update completed in 2000 and a Phase I ESA update completed in 2005.
   - The site visit and records review did not indicate any new significant environmental concerns at the site.
3. EXP Services Inc., Phase I Environmental Site Assessment,112 Montreal Road, Ottawa, Ontario, December 20, 2013.

   No significant changes to the site were noted compared to the 2010 Phase I ESA.

   The report compared soil results from previous site investigation to the updated July 2011 MOE soil and groundwater standards. The concentrations of the analysed parameters in both soil and groundwater samples were generally less than the MOE Table 3 standards for residential land use. There were two soil exceedances for lead and arsenic in the samples taken from under the north part of the Parkway building. Both soil samples were collected in the basement of the building from the top 0.15 m of soil. The metals concentrations were noted to be significantly lower in soil samples collected from the test pits and boreholes to the south and west, therefore the metals impacted soil was considered to be delineated in those directions. However, the metals impact was not delineated to the east. Minor PHC impact to soil was found in two boreholes located just to the west of the north part of the Parkway building. PHC impacts were considered to be delineated to the east, west and south.

Petroleum impacted groundwater was documented immediately west of the north part of the Parkway building. The groundwater impact was considered to be delineated to the south and west by existing monitoring wells. Minor PHC impacts were noted in three shallow bedrock monitoring wells located east of the Parkway building. EXP confirmed that these wells are still present and recommended that these wells be resampled.

Five PCAs resulting areas of potential environmental concern were identified:

- Fill material of unknown quality on the site (soil with metals impact previously collected on the site)
- Gas station at 120 Montreal Road (northeast adjacent)
- Dry cleaners at 94 Montreal Road (northwest adjacent)
- Former bulk fuel depot at 239 Kendall Avenue (30 m east)

A Phase II ESA was recommended to address these PCAs.

4. Phase II Environmental Site Assessment, 112 Montreal Road, Ottawa, Ontario, January 2014 prepared by EXP Services Inc.

   The Phase II ESA was conducted to address the APECs identified the 2013 Phase I ESA. A total of ten boreholes were advanced at the site, nine of which were completed as monitoring wells.

   The generally stratigraphy at the site consisted of silty sand and gravel fill overlying native silty sand and gravel till. Limestone bedrock was encountered in all of the boreholes between 2.3 and 3.3 metres below ground surface. Groundwater flow direction was determined to be to the northeast.

   Six soil samples were submitted for analysis of PHC and metals. One soil sample exceeded the MECP Table 3 SCS for PHC F3, three soil samples also exceeded the applicable standards for barium, lead, and/or zinc. The remainder of the soil samples were within the Table 3 SCS for all parameters analysed. The estimated volume of PHC impacted soil was 350 m3. Metals impacted soil was identified in two sperate areas on the site. The estimated volumes of metals impacted soil was approximately 1,050 m^3 and 315 m^3 respectively.

   Groundwater samples were collected from seven of the newly installed monitoring wells, and two previously existing monitoring wells and were submitted for analysis of PHC and VOC. All groundwater samples were within the Table 3 SCS for all of the parameters analyzed.

5. Soil Characterization Report 112 Montreal Road, Ottawa, Ontario dated November 21, 2022, prepared by EXP Services Inc.

   - The main objective of this site characterization investigation was to collect soil samples for laboratory analyses for the preparation of Excess Soil Management Plan (ESMP).

6. Phase One Environmental Site Assessment 112 Montreal Road, Ottawa, Ontario dated April 2023, prepared by EXP Services Inc. The review of the report identified the followings:

   - Based on a review of historical aerial photographs, historical maps, and other records, the Phase One property was first developed for residential purposes prior to 1912. The property was re-developed as a motel *circa* 1952 and operated as such until *circa* 2017. The motel buildings were demolished in 2019 and the Phase One property has been vacant since.
   - The most recent use of the property was as a motel, which is defined in O.Reg 153/04 as a commercial land use. It is proposed that residential buildings be constructed on the Phase One property. As the proposed land use is more sensitive than the previous land use, a Record of Site Condition (RSC) is required.

- Based on the review of the Phase One ESA, six (6) areas of potential environmental concern (APEC) were identified:

Area of Potential Environmental Concern (APEC)	Location of APEC on Phase One Property	Potentially Contaminating Activity (PCA)	Location of PCA (On-Site or Off-Site)	Contaminants of Potential Concern	Media Potentially Impacted (Groundwater, Soil and/or Sediment)
1. Impacted fill material on the site	Entire Phase One property	PCA #30 – Importation of fill material of unknown quality	On-site	Benzene, toluene, ethylbenzene, xylene (BTEX), and petroleum hydrocarbons (PHC), metals	Soil
2. Gas station at 120 Montreal Road	Northeast corner of Phase One property	PCA #28 – Gasoline and Associated Products Storage in Fixed Tanks	Off-site	BTEX, PHC	Groundwater
3. Former dry cleaner at 90 Montreal Road	Northwest corner of Phase One property	PCA #37 – Operation of dry-cleaning equipment (where chemicals are used)	Off-site	Volatile organic compounds (VOC)	Groundwater
4. Former oil warehouse at 296 Kendall Avenue	Area along east property line	PCA #28 – Gasoline and associated products in fixed tanks	Off-site	BTEX, PHC	Groundwater
5. Former gas station at 138 Montreal Road	Area along east property line	PCA #28 – Gasoline and associated products storage in fixed tanks	Off-site	BTEX, PHC	Groundwater
6. Former rail line east of the site	East part of Phase One property	PCA #46 – Rail yards, tracks, and spurs	Off-site	PHC, polycyclic aromatic hydrocarbons (PAH), metals	Groundwater

Based on the findings of Phase I ESA, a Phase Two ESA was conducted to address the APEC identified.

1. Phase Two Environmental Site Assessment 112 Montreal Road, Ottawa, Ontario dated April 2023, prepared by EXP Services Inc. The review of the report identified the followings:
   - Nine (9) test pits (TP1 to TP9) were excavated at the Site using a rubber-tire excavator, under the full-time supervision of EXP staff. The test pits were excavated to a maximum depth of 2.2 metres below ground surface (m bgs) or refusal due to the presence of bedrock.
   - Six boreholes (BH-1 to BH-6) and ten auger holes (AH1 to AH10) were advanced at the site by a licensed well driller, under the full-time supervision of EXP staff. The boreholes were drilled to a maximum depth of 4.4 m bgs or refusal due to the presence of bedrock. Bedrock was cored in all six boreholes to a maximum depth of 15.3 m bgs. The auger holes were drilled to a maximum depth of 2.9 mbgs.
   - Two soil samples exceeded the Table 3 SCS for copper, lead, and/or mercury, and five soil samples exceeded for conductivity, and five soil samples exceeded for PHC.
   - An additional five boreholes (MW23-1 to MW23-5) were advanced at the Phase Two property. Bedrock was air hammered in the five boreholes to a maximum depth of 7.3 m bgs. All five of the boreholes were completed as monitoring wells.
   - Eight groundwater samples and one duplicate sample were submitted for chemical analysis of PHC, PAH, VOC and metals parameters. There were no exceedances of the MECP 3 SCS for any of the parameters analyzed.

- All of the exceedances in soils were limited to metals parameters and PHC fractions F2 and F3. There were no groundwater exceedances of the Table 3 SCS for any of the parameters analyzed. It was recommended that the impacted soil at Phase Two be removed prior to re-development.

2 Hydrogeological Setting

2.1 Regional Setting

2.1.1 Regional Geology

The Site is located on the southwest corner of the intersection of Vanier Parkway and Montreal Road in Ottawa, Ontario. The entire Site comprises a total area of approximately 1.15 hectares. The physiography of the area corresponds to what is identified as Limestone Plains. The review of surficial geological mapping information indicates that on a regional scale the undifferentiated till from Pleistocene, with predominantly sandy silt to silt matrix, commonly rich in clasts, often high in total matrix carbonate content is the dominant soil type encountered at the surface. Figure 2 shows the Regional Surficial Geology.

The surficial till is underlain by bedrock comprising of middle Ordovician massive to thick bedded limestone with thin shale partings identified as Ottawa Group.

The regional groundwater flow direction is to the west towards Rideau River which is approximately 350 to the west of the Site.

2.1.2 Regional Hydrogeology

Based on geological mapping information and review of MECP water well information database the regional aquifer that supplied most of the drinking water is the bedrock. However, bedrock in the area is no longer used as a drinking water source. The surficial geology of the Site is comprised of undifferentiated predominantly sandy silt to silt till, commonly rich in clasts often high in total matrix carbonate content on Paleozoic terrain as shown on Figure 3. The bedrock at the site is limestone with shaley partings of the Ottawa Formation as shown on Figure 3.

The fractured limestone bedrock is considered the regional aquifer in the area as most of the recorded water wells are completed in the bedrock. The test pumping rates as recorded varied between 13.6 to 59 litres/minute (LPM).

The general stratigraphy at the Site, as revealed in the on-Site borehole logs, consists of asphalt at surface, underlain by reworked sand and gravel fill material overlying layers of sandy silt to silt till, overlying weathered limestone bedrock.

The Site stratigraphic characteristics are summarized in Table 2.1.

Table 2.1: Site Stratigraphy

Stratigraphy	Details	Minimum Thickness (m)	Maximum Thickness (m)	Approximate Range of Top Elevation (m ASL)
Surface	Asphalt	0.06	0.14	55.89 – 57.01
	Fill – imported silt, sand and gravel	0.10	2.90	55.8 – 56.96
Overburden	Till – sandy gravelly till with some silt	0.40	2.40	53.40 – 56.10
Bedrock	Limestone with shale partings	Bottom of bedrock was not encountered at any of the drilled locations.		52.10 – 55.38

mbgs = meters below ground surface

The MECP water well records search indicate local geology is clay, sand and silt, with stones over limestone bedrock. The depth to bedrock is approximately 1 to 9 m below grade. There are no water bodies within the subject site. The closest body of water is the Rideau River located approximately 350 m west of the site. Based on monitored groundwater level measurements at the site, the groundwater flow is inferred to be to the west.

2.1.3 MECP Water Well Record Review

Water Well Records (WWRs) were searched from the database maintained by the Ministry of the Environment, Conservation and Parks (MECP) and reviewed to determine the number of water wells documented within a 500-m radius of the Site boundary. The locations of the MECP WWRs are shown on Figure 4. A summary of the WWR is included in Appendix A.

The MECP WWR database indicates that there were forty-five (45) wells within 500 m search distance from the Site boundaries (Figure 3 and Appendix A).

The reported static water elevations ranged between 50.2 masl to 62.9 masl (5.4 to 0.9 mbgs). A summary of the MECP well record search is provided in the table below.

<table>
<tr><th></th><th>Water Found Elevation Range (masl)</th><th>Well Depth Range (mbgs)</th><th>Test Pumping Rate Range (LPM)</th><th>Comments</th></tr>
<tr><td rowspan="2">Bedrock Wells (10)</td><td>-170.5 to 49.3</td><td>17.9 to 226.1</td><td>13.6 to 49.3</td><td>Two (2) Geothermal
Two (2) industrial water supply
Six (6) domestic water supply</td></tr>
<tr><td colspan="3">Bedrock wells completed between 1949 and 1951</td><td></td></tr>
<tr><td>Incomplete Well Records (35)</td><td colspan="3">Incomplete well records, wells completed between 2004 and 2015.</td><td>All these wells with incomplete records are classified as monitoring and test holes, observation wells, or are abandoned wells.</td></tr>
</table>

Flowing wells were not identified in the area. Based on the date of installation information of the wells, most of the water supply wells were constructed in late 1950s. Since the area is municipally serviced, it is unlikely that except the geothermal wells, the remaining water supply wells are still active.

2.2 Site Setting

2.2.1 Site Topography

The Site topography is flat. The regional slope is to the west. Currently, the two property blocks (Phase One the north block and Phase Two the south block) are vacant. The east part of the Phase Two property had been excavated to the bedrock surface, and ponded water was present. The west part of the south block was paved or had a former building. Historically, the site operated as a motel and was occupied by seven buildings including a laundry building, restaurant, and what was formerly a detached residence. All of the site buildings were demolished and removed in 2019.

The regional topography slopes downwards to the west. The local groundwater flow direction is anticipated to be west/northwest towards the Rideau River.

2.2.2 Local Surface Water Features

There are no water bodies on the subject site. The closest body of water is the Rideau River located approximately 350 m west of the site.

2.2.3 Local Geology and Hydrogeology

A summary of subsurface soil stratigraphy is provided in Table 2.1. The soil descriptions are based on the Phase Two ESA report (EXP, 2023). They are summarized for the hydrogeological interpretations. As such, the information provided in this section shall not be used for construction design purposes.

The following is a brief description of the soil conditions encountered during the investigation.

Asphalt and Fill

The surface material at majority of the boreholes consisted of asphalt and fill of anthropogenic origin, with a combined maximum thickness of 3.04 m. The fill as encountered is composed of silt, sand and gravel. This material extends to up to 55.8 to 56.96 masl elevation from ground surface. The maximum thickness of anthropogenic surficial material was 2.9 m encountered at MW23-01.

Glacial Till Overburden

The native soil encountered at the Site generally consisted till composed of sandy gravel and silt. The till extended down to the bedrock surface which was encountered between elevations of 52.1 to 55.38 masl. The maximum thickness of till encountered at the Site was 2.4 m at BH13-7.

Limestone Bedrock

Bedrock at the Site was encountered at elevations ranging between 52.1 and 55.38 masl. The bedrock consisted of shaly limestone, with shaly partings along the bedding planes sometimes containing cross beddings, major joints are near vertical in orientation and moderately to widely spread.

The borehole and monitoring well locations are shown on Figures 5A and 5B. Geological cross-sections were generated based on the borehole logs completed as part of the previous and current investigations and are shown on Figures 6A (Cross sections A-A' and B-B') and Figure 6B (Cross sections C-C' and D-D'). The cross sections show a simplified representation of soil conditions and soil deposits may be interconnected differently than represented. Borehole logs used to generate the cross-sections are provided in Appendix B.

3 Groundwater Conditions

Groundwater condition at the Site are monitored via the monitoring wells (MW) installed at the Site during previous (2013 and 2022) and recent investigations in 2023. There are twenty (20) groundwater monitoring wells installed at the site. Some of the MWs have been destroyed or decommissioned and are no longer available. Out of these twenty (20) MWs, two (2) wells (BH 13-1A and BH 13-3) are installed in the shallow fill and till soils and the remaining eighteen (18) wells are installed in the bedrock. The diameter of all monitoring wells is 50 mm. The screen length varied between 1 m to 3 m. Borehole logs and monitoring well installation details are provided in Appendix B. The monitoring well locations are shown on Figure 5A and 5B.

3.1 Water Level Monitoring

As part of the ongoing monitoring activities at 112 Montreal Road, Ottawa, Ontario, static water levels in the monitoring wells were recorded on October 30, November 14, 2013, September 15, 2022, February 9 and 27, 2023. A summary of all groundwater level data is given in Table 3-1 below.

The site wide groundwater elevations ranged between 50.6 masl to 55.24 masl.

Table 3-1: Monitored Groundwater Elevations, 112 Montreal Road, Ottawa

BH ID	Ground Surface Elevation (masl)	10/30/2013	11/14/2013	9/15/2022	2/9/2023	2/27/2023
BH 13-1A	56.5	54.10	54.06			
BH 13-1B	56.48	52.58	52.63			
BH 13-2	56.13	53.23	53.25			
BH 13-3	56.13	53.73	53.72			
BH 13-4	56.23	53.13	53.35			
BH 13-5	55.89	52.39	52.44			
BH 13-6	56.26	52.16	52.20			
BH 13-7	56.24	53.54	53.52			
BH 13-8	56.4	52.20	52.20			
BH 13-9	57.01	53.61	53.64			
BH-01	55.38			54.88		53.18
BH-02	54.08			53.28		53.19
BH-03	56.5			52.70		
BH-04	56.1			50.60		51.12
BH-06	55.84			55.24		
MW23-1	56.37				52.67	
MW23-2	54.26				52.96	
MW23-3	54.27					
MW23-4	56.3				54.10	
MW23-5	56.96				54.06	

Note: Elevations were collected using a high precision GPS unit with a geodetic elevation relative to mean sea level.
masl – metres above sea level
NM – not measured

Based on the collected groundwater data from February 2023 the groundwater flow from the site is inferred to be to the west, southwest and to the north as shown on Figure 7. The most recent groundwater data indicates that a groundwater mound exists near the northeast portion of the site where the ground surface have been excavated and temporary ponding of surface water is occurring.

Groundwater levels are expected to show seasonal fluctuations and vary in response to prevailing climate conditions. This may also affect the direction and rate of flow. It is indicated by the groundwater monitoring data that the yearly site-wide variation is consistent, 1.3 m to 1.4 m between 2020 and 1.4 m 2022 and as expected low elevations were noted during the winter season and higher elevations in the summer.

3.2 Hydraulic Conductivity Testing

Single Well Response Tests (SWRT's) were completed in three (3) monitoring wells (MW23-2, MW23-4 and MW23-5) on March 3, 2023. The tests were completed to estimate the saturated hydraulic conductivity (K) of the material at the well screen depths.

The static water level within each monitoring well was measured prior to the start of testing. In advance of performing SWRTs, each monitoring well underwent development to remove fines introduced into the wells following construction. The development process involved purging of the monitoring wells by removing three volumes of well water to induce the flow of fresh formation water through the screen. Each monitoring well was permitted to fully recover prior to performing SWRTs.

Hydraulic conductivity values were calculated from the SWRT and constant rate test data as per Bouwer and Rice solution included in the Aqtesolv Pro. V.4.5 software package. The data and the results of the analyses are included in Appendix C.

A summary of the hydraulic conductivities (K-values) estimated from the SWRTs are provided in Table 3-2.

Table 3-2: Summary of Hydraulic Conductivity Testing

Well ID	Screened Material	K value (m/sec) using Bouwer and Rice solution	Recovery (%)	Time (min)
MW23-2	Fair to poor quality bedrock	7.16E-07	77	58
MW23-4	Fair to poor quality bedrock	1.88E-06	96	29
MW23-5	Fair to poor quality bedrock	2.99E-07	58	69
	Geometric Mean	**7.39E-07**		

SWRTs provide hydraulic conductivity estimates of the geological formation surrounding the well screens and may not be representative of bulk formation hydraulic conductivity. As shown in Table 3-2, the highest K-value of the tested water-bearing zone is 1.88E-06 m/s, and the geometric mean of the K-values is 7.39E-07 m/s. As a reasonable approach the geometric mean K-value will be used in the dewatering assessment calculations.

3.3 Groundwater Quality

To assess the suitability for discharging pumped groundwater into the sewers owned by the City of Ottawa during dewatering activities, one (1) groundwater sample was collected from monitoring well MW23-1 on March 2, 2023, using a peristaltic pump. Prior to collecting the noted water sample, approximately three (3) standing well volumes of groundwater were purged from the referred well. The samples were collected unfiltered and placed into pre-cleaned laboratory-supplied vials and/or bottles provided with analytical test group specific preservatives, as required. Dedicated nitrile gloves were used during sample handling. The groundwater samples were submitted for analysis to Caduceon Laboratories, a CALA certified independent laboratory in Ottawa, Ontario. The analytical results are provided in Appendix D.

When comparing the chemistry of the collected groundwater samples to the City of Ottawa Sewer Use Criteria, there were no exceedances of any of the tested parameters.

For the short-term dewatering water discharge (during construction phase), it is anticipated that TSS levels and some other parameters (for example, Total Metals) in the pumped groundwater may become elevated and temporarily exceed both, Sanitary and Storm Sewer Use By-Law limits. To mitigate the anticipated elevated concentrations of TSS and associated metals, suitable best management practice (BMP) treatment methods (fine mesh filter bags, settling tanks) should be utilized or be implemented. The measures shall be installed prior to commencement of construction. The treatment systems will need to be adjusted or adapted for efficient reduction of the exceeded parameters to the compliance criteria limit before the discharge can be directed to the receptors.

For the long-term dewatering discharge to the city storm sewer system (post-development phase) and based on the water quality test results, no treatment system will be required. If long-term discharge is anticipated from the site then a discharge agreement with the City of Ottawa will be required for discharge.

For the long-term dewatering discharge to the storm sewer system (post-development phase) and based on the water quality results, no treatment system will be required. The water quality results presented in this report may not be representative of the long-term condition of groundwater quality onsite. As such, regular water quality monitoring is recommended for the post-construction phase, as required by the City of Ottawa.

An agreement to discharge into the sewers owned by the City of Ottawa will be required prior to releasing dewatering effluent to the city owned sewer.

4 Dewatering Assessment

The dimensions of the proposed structure to support the dewatering assessment are summarized in Table 4-1 below.

Table 4-1 Building Dimensions for Dewatering Assessment

Input Parameter	Input Parameters	Units	Notes
Number of Underground Parking Levels	4 Level	-	
Ground Elevation	57.48	masl	Lowest ground elevation based on the ground surface elevations surveyed at the MW locations on Site.
Underside Elevation of P4 Slab	44.8	masl	Assumed to be 13 m below existing ground elevation based on four (4) levels of underground parking.
Lowest Footing Elevation	43.8	masl	Elevator Shafts - Assumed to be 1.0 m below the underside of foundation slab elevation.
Excavation Area			Approximate area (length x width) of the proposed excavation area.
Phase 1 Construction Area	5,263	m^2	
Phase 2 Construction Area	2,910	m^2	

4.1 Dewatering Flow Rate Estimate and Zone of Influence

The dewatering flow rates are estimated based on some key parameters such as groundwater levels, hydraulic conductivity value, size and depth of the excavations. It is expected that the initial dewatering rate will be higher to remove groundwater from within the overburden formation. The dewatering rates are expected to decrease once the target water level is achieved in the excavation footprint as groundwater will have been removed, primarily from storage, resulting in lower seepage rates into the excavation For the dewatering assessment at a location, careful review of water level information, the highest recorded water level from the site monitoring well was used in the dewatering calculations. The required hydraulic conductivity (K) values used in the calculations is the geometric mean value determined from the results of analyses of single well response or hydraulic conductivity tests completed at wells across the Site.

The dewatering flow equation is based on the following general hydrogeological and construction considerations and assumptions:

- Aquifer top, bottom and initial ground water levels and aquifer type were established based on borehole logs and monitoring well information;
- The bottom of the aquifer is the limit of dewatering;
- In situations where the aquifer bottom was not encountered within the borehole depths, the aquifer was assumed to continue a few metres below the foundation elevation;

- The hydraulic conductivity 'K' for the aquifer parameter is based on the geometric mean values from testing performed at the Site. Other aquifer parameter such as storage coefficient 'S' were estimated based on field evidence and aquifer type;
- The aquifer is assumed to be isotropic and homogenous in both the horizontal and vertical directions. In reality, the aquifers are anisotropic and heterogeneous in all directions;
- The aquifer is assumed to be infinite in extent. In reality, the extent of the aquifer is limited by high horizontal variability fracture zones and the variations in the overburden sediments;
- It was assumed that dewatering occurs across the full vertical extent of the aquifer (i.e., assumes fully penetrating wells). In practice, dewatering will occur only a limited thickness within the upper portion of the aquifer; and,
- Excavations will extend to 1.0 m below the invert for placement of subgrade or bedding material and that is the target groundwater lowering elevation.

Dewatering in a source area will create a zone within which the groundwater will be lowered from its initial water level. Each zone of influence (ZOI) is dependent on the anticipated pumping duration, continuity of the aquifer, aquifer parameters (hydraulic conductivity, storativity) and required drawdown. For the purposes of this report, the limit of the ZOI is considered the distance beyond which the predicted drawdown will be 0.5 m or less. This drawdown cut-off criterion is considered reasonable and appropriate considering 0.5 m of drawdown is within the range of natural groundwater variation range. The estimated ZOIs are based on reasonable worst-case scenarios assumed for the dewatering evaluation. The dewatering equations are shown in Figure DW-1 in Appendix E.

For dewatering flow volume calculations, a Factor of Safety (FoS) approach will be used. In this approach, the flow volume requested for permit or EASR application will be 1,5 times of what is estimated by the modified non-equilibrium flow equation by Cooper and Jacob (Powers et al., 2007). The FoS approach provides a higher than calculated volume of flow and provides the dewatering contractor flexibility to compensate for unforeseen groundwater conditions that they may encounter during construction.

4.2 Cooper-Jacob's Radius of Influence

The radius of influence ($\mathrm{R}cj$) for the construction dewatering was calculated based on Cooper-Jacob's equation. This equation is used to predict the distance at which the drawdown resulting from pumping is negligible.

The estimated radius of influence due to pumping is based on Cooper-Jacob's formula as follows:

$$\mathrm{R}_{cj} = \sqrt{2.25KDt/s}$$

Where:

$\mathrm{R}cj$ = Estimated radius of influence (m)

D = Aquifer thickness (original saturated thickness) (m)

K = Hydraulic conductivity (m/s)

S = Storage coefficient

t = Duration of pumping (s)

4.3 Stormwater

Additional pumping capacity may be required to maintain dry conditions within the excavation during and following significant precipitation events. Therefore, the dewatering rates at the Site should also include removing stormwater from the excavation.

A 20.2 mm precipitation event resulting from 15-minute of rainfall from a 10-yr storm event was utilized for estimating the maximum stormwater volume. The calculation of the stormwater volume is included in Appendix E.

The estimate of the stormwater volume only accounts for direct precipitation over the excavation. The dimensions of the excavation are considered in the dewatering calculations. Runoff which originated outside of the excavation's footprint is excluded and it should be directed away from the excavation.

During precipitation events above this estimated rainfall amount measures should be taken by the contractor to retain stormwater onsite in a safe manner to not exceed the allowable water taking and discharge limits, as necessary. A two (2) and a one hundred (100) year storm event over a 30-minute period are 16.2 and 36.0 mm (refer to Appendix E).

4.4 Results of Dewatering Rate Estimates

4.4.1 Construction Dewatering Rate Estimate

For this assessment, it was assumed that the proposed construction plans include an excavation with shoring extending to the Site boundaries. EXP should be retained to review the assumptions outlined in this section, should the assumed shoring design change. Estimated dewatering rates are presented in Appendix E.

Based on the assumptions provided in this report, the results of the dewatering rate estimate can be summarized as follows:

Table 4-2 Summary of Construction Dewatering Rates

Peak Dewatering Flow Rate (Litres/day) and Zone of Influence (ZOI) in m		
Description	Phase 1 Construction Area (Building A and Tower B1) 4 Levels of **Underground Parking**	Phase 2 Construction Area (Towers B2 and B3) 4 Levels of **Underground Parking**
Total Volume (L/day) Short Term Discharge of Groundwater (Construction dewatering) **without Safety Factor (excluding precipitation)**	96,188 LPD	48,960 LPD
Total Volume (L/day) Short Term Discharge of Groundwater (Construction dewatering) **with 1.5x Safety Factor (excluding precipitation)**	144,290 LPD	73,440 LPD
Stormwater volume accumulated from a 15-minute rainfall from a 10-yr return storm event – 20.2 mm over the excavated area	Phase 1 Area – 5,263 m^2 106,313 L	Phase 2 Area – 2,910 m^2 58,782 L
Maximum Volume (L/day) Short Term Discharge of Groundwater (construction dewatering) **with Safety Factor and including 10-yr storm precipitation for permitting requirement**	250,603 LPD	132,222 LPD
Total Maximum pumping Rate to be Requested for permitting	382,826 LPD	
Predicted ZOI (in m) due to short-term construction dewatering pumping	35 m	31 m

The peak dewatering flow rates do not account for flow from utility beddings and variations in hydrogeological properties beyond those encountered during this investigation. Three dewatering pumping scenarios were evaluated using minimum, geometric mean, and maximum hydraulic conductivity values estimated from single well response tests. Most reasonable pumping volume estimate is the ones using the geometric mean of the estimated hydraulic conductivity value. The pumping rates provided in Table 4-2 above are the result of using the geometric mean hydraulic conductivity value.

In terms of permitting requirements, it should be noted that with factor of safety of 1.5, and considering a cautious and conservative approach (pumping from an excavation without barrier walls) with an estimated pumping rate of 382,825 LPD volume, registration with the Environmental Activity and Sector Registry (EASR) with the MECP will be required.

All grading around the perimeter of the excavation should be graded away from the shoring systems and ramp/site access to redirect runoff away from excavation.

The contractor is responsible for the design of the dewatering systems (depth of wells, screen length, number of wells, spacing, sand pack around screens, prevent soil loss etc.) to ensure that dry conditions are always maintained within the excavation at all costs.

Dewatering should be monitored using dedicated monitoring wells within and around the perimeter of the excavation, and these wells should be monitored both by manual measurements and with electronic data loggers; records should be maintained on site to track dewatering progress. Discharge rates should be monitored using calibrated flow meters and records of dewatering progress, and daily precipitation as per MECP requirements.

4.4.2 Post-Construction Dewatering Rate Estimate

It is our understanding that the development plan includes a permanent foundation sub-drain system that will ultimately discharge to the municipal sewer system if conventional footings are installed. The long-term dewatering was based on the same equations as construction dewatering shown in Section 4.1.

The calculation for the estimated flow to the future sub-drain system (with no cutoff walls) is provided in Appendix E. The dewatering target for the foundation drainage system is taken at 0.5 m below the lowest slab elevation.

The foundation drain analysis provides a flow rate estimate. Once the foundation drain is built, actual flow rate measurements of the sump discharge will be required to confirm the estimated flow rate.

Based on the assumptions provided in this report, the estimated sub-drain discharge volumes are summarized in Appendix F. Seasonal and daily fluctuations are expected. These estimates may be affected by hydrogeological conditions beyond those encountered at this time, fluctuations in groundwater regimes, surrounding Site alterations, and existing and future infrastructures.

Table 4-3: Summary of Foundation Drainage Pumping Rate

Long-Term Dewatering Flow Rate	Phase 1 Construction Area (Building A and Tower B1) 4 Levels of Underground Parking	Phase 2 Construction Area (Towers B2 and B3) 4 Levels of Underground Parking
Total Volume (LPD) Long-Term Drainage of groundwater (from foundation weeping tiles, sub slab drainage)	48,100	24,500
Total FDC Rate for the site LPD =	72,600	
Predicted ZOI (in m) due FDC (Foundation Drainage Collector) pumping in the long-term (assuming pumping for 365 days)	35 m	31 m

The sub-drain drainage rate estimate is based on the assumptions outlined in this report. Any variations in hydrogeological conditions beyond those encountered as part of this investigation may significantly influence the sub-drain discharge volumes.

4.4.3 Phasing in Construction Dewatering

The site will be constructed in two (2) phases. The Building A and Tower B1 in the northern portion of the site will be built in the first phase. Towers B2 and B3 will be built in the second phase. It was assumed that all of the towers will have 4 levels (P4) of underground parking garage. Though work will be completed in two (2) phases for the permitting it is recommended to apply for the EASR permit considering the total of Phase 1 and 2 pumping rates of 382,825 LPD volume. This higher rate will provide ample flexibility to the constructor if unforeseen ground conditions are encountered during construction of any of the two phases. Also, with this approach separate EASR registration will not be required for each phase of construction.

4.5 MECP Water Taking Permits

4.5.1 Short-Term Discharge Rate (Construction Phase)

In accordance with the Ontario Water Resources Act, if the water taking for the construction dewatering is more than 50,000 L/day but less than 400,000 L/day, then an online registration on Environmental Activity and Sector Registry (EASR) with the MECP will be required. If the estimated dewatering pumping rate exceeds 400,000 L/day, a Category 3 Permit to Take Water (PTTW) will be required from the MECP.

As of July 1, 2021, an amendment of O. Reg. 63/16 has come into effect and replaced the former subsection 7 (5) such that the EASR water taking limit of 400,000 L/day would apply to groundwater takings of each dewatered work area only, excluding stormwater.

As a conservative approach it is recommended to consider 382,825 L/day as the anticipated maximum pumping rate for the site. Based on the MECP construction dewatering permit policy an EASR registration will be required to facilitate the construction dewatering program for the Site. This FoS approach rate is reasonable and is inclusive of the additional volume resulting from a 10-yr storm event.

A Groundwater Discharge Plan (showing dewatering system configuration including pumping line and discharge treatment setup sketch) must be developed by the dewatering specialist contractor and must be reviewed by the hydrogeological consultant on record. A recommended monitoring and mitigation plan for potential impacts from the proposed construction dewatering will be developed which will be in effect during construction.

A groundwater discharge management plan has been developed and provided in Table 6-1.

An assessment of consolidation and settlement from the proposed dewatering operation will be required to assess potential impact of groundwater lowering on the engineered structures (building foundations, municipal infrastructures) that are located within the predicted Zone of Influence (ZOI).

A private dewatering discharge agreement with the city of Ottawa must be in place before directing any construction dewatering discharge from the site into the City-owned sewer infrastructures. If for some unavoidable reason the dewatering has to commence prior to signing this agreement with the City, the discharge cannot be directed towards the city sewers and must be stored onsite or hauled to an off-site location.

The permit, discharge plan, hydrogeological investigation report, and a geotechnical assessment of settlements must also be available at the construction Site during the entire construction dewatering period. EXP should be notified immediately about any changes to the construction dewatering schedule or design, since the EASR will need to be updated to reflect these modifications. Altogether, the hydrogeological report, EASR, Discharge Plan and geotechnical assessment constitute the Water Taking Plan which needs to be available on the site during the construction dewatering.

4.5.2 Long-Term Foundation Drainage Pumping Rate (Post Construction Phase)

In accordance with the Ontario Water Resources Act, if the long-term water taking for foundation drainage is more than 50,000 L/day, then a Category 3 Permit to Take Water (PTTW) will be required from the MECP.

Based on the foundation drainage estimate 72,600 L/day shown in Table 4-3 which is more than 50,000 L/day, a Category 3 Permit to Take Water (PTTW) will be required to facilitate long-term foundation drainage discharge from the site during the post-development phase.

The applied analytical formula is adequate for long-term (steady state) conditions as it omits specific yield and time dependency. When the formula is used for short-term conditions a larger safety factor is recommended to cover a larger initial dewatering rate, which is required to remove stored groundwater.

5 Environmental Impact

5.1 Surface Water Features

The topography of the area is relatively flat with a gradual slope to the northwest, towards the Rideau River which is 350 m to the west. Due to the limited extent of zone of influence and the larger distance to the nearest surface water feature, no detrimental impacts on surface water features are expected during construction activities.

5.2 Groundwater Sources

Well Records from the MECP Water Well Record (WWR) Database were reviewed to determine the presence and number of former water supply wells within a 500 m radius of the Site boundaries. The area is highly urbanized and serviced by municipal services wells are not used for drinking water needs. So therefore, no dewatering related impact is not expected or relevant.

5.3 Geotechnical Considerations

We do not anticipate any impacts on engineered structures from proposed limited duration dewatering and long-term foundation drainage from the site. However, an engineering analysis of consolidation and settlement from this low volume pumping is highly recommended to assess potential impacts of groundwater lowering on municipal infrastructures and engineered structures or building foundations that are located within the estimated ZOI of the site.

5.4 Groundwater Quality

It is our understanding that the effluent from the dewatering system during the construction in the post remedial stage will potentially be released into the municipal sewer system. As such, the quality of groundwater discharge is required to conform to the City of Ottawa Sewer Use By-Law.

Dewatering (short and long-term) may induce migration of contaminants within the zone of influence and beyond due to changing hydraulic gradients, hydrogeological conditions beyond Site boundaries and preferential pathways in utility beddings etc. The water quality sampling conducted as part of this assessment was performed under static conditions. As a result, monitoring may be required during dewatering activities (short and long-term) to monitor potential migration, and this should be performed more frequently during early dewatering stages.

Based on the water quality results both the short- (during construction) and long-term (post-development phase) discharge to the City of Ottawa sewer system, it is recommended to implement a groundwater quality sampling, monitoring and mitigation plan for monitoring of discharge water quality. The water quality results presented in this report are a snapshot of the quality and may not be representative of the long-term condition of groundwater quality onsite. As such, regular water quality monitoring is recommended for the post-construction phase as required by the City of Ottawa.

An agreement to discharge into the sewers owned by the City of Ottawa will be required prior to releasing dewatering effluent.

5.5 Well Decommissioning

In conformance with Regulation 903 of the Ontario Water Resources Act, the installation and eventual decommissioning of any dewatering system wells or monitoring wells must be completed by a licensed well contractor. This will be required for all wells that are no longer in use.

6 Discharge Management Plan

The following section provides a recommended discharge management plan for the proposed dewatering operation at the site. The recommended plan is also summarized in Table 6-1. It is anticipated that the discharge from the site when compliant will be directed to the City of Ottawa sewer services. The discharge water quality shall be monitored as per recommended frequencies. If at any point of time the discharge is deemed non-compliant for routing into the city sewers, the pumped water either be stored onsite for treatment or be hauled offsite by a licensed hauler to a designated and licensed site that will accept the discharge.

An engineering settlement analysis will be required for assessment of the potential impacts of the short-term dewatering operation. A settlement monitoring plan will need to be developed by establishing settlement monitoring benchmark stations and setting up trigger levels at monitoring wells. Mitigation measures will be required when the established trigger levels are exceeded and an investigation will be required to assess the conditions.

Erosion will not be an issue at the site given the proposed dewatering operation, however the sediments that will be generated due to excavation and has the potential to be an issue. An adaptive sediment control plan shall be developed and be implemented at the site during construction to control impacts from sediments. Therefore, sediment control measures (as outlined in the Table 6-1) will need to be installed at the Site that will be inspected on regular intervals and within 24 to 48 hours after storm events.

Table 6-1 Discharge Management Plan

7 Conclusions and Recommendations

Based on the findings of the 112 Montreal Road, Ottawa, Ontario, the following conclusions and recommendations are provided:

- When comparing the chemistry of the collected groundwater samples to the City of Ottawa Sewer Use Criteria, there were no exceedances of any of the tested parameters.
- Based on the assumed site conditions for the two phases of construction evaluated, the estimated maximum factor of safety dewatering rate (including storm water input volume) for the proposed construction activities is approximately 454,000 LPD. This is the rate that should be used for the EASR regsitration;
- The long-term foundation drainage flow rate from the site is estimated to be approximately 48,100 LPD. It is recommended that once the sub-drain system is in place, a flow meter be installed at the sump(s) to record daily discharge volumes during the commissioning stage of the system to record pumping rates. A PTTW will be required for long-term discharge;
- The construction dewatering and long-term estimate of sub-drain discharge volumes is based on the assumptions outlined in this report. Any variations in the building design (change in parking level foundation elevation) or encountering a different hydrogeological conditions beyond those encountered as part of this preliminary investigation may significantly influence the discharge volumes;
- For the short-term dewatering system (construction phase), it is anticipated that TSS levels and some other parameters (for example, Total Metals) in the pumped groundwater may become elevated and exceed both, Sanitary and Storm Sewer Use By-Law limits. To control the concentration of TSS and associated metals, it is recommended that a suitable treatment method be implemented (filtration or decantation facilities and/ or any other applicable treatment system) during construction dewatering activities. The treatment system will be adaptive and will need to be modified if water quality is not improved to the water quality criteria of the receptor system;
- Groundwater discharge treatment (for TSS) systems shall be installed at the site prior to any dewatering discharge is released into the city sewers. If non-compliance is indicated by sampling that discharge to the city services shall be discontinued in the interim. To contain the discharge onsite, temporary discharge storage options (storage tank, envirotank™) may have to be used until such time that the pumped groundwater is deemed compliant for discharge into the city sewers.
- As per the MECP technical requirement for PTTW and EASRs, the geotechnical assessment of the stability of the soils due to water taking (ex: settlement, soil loss, subsidence etc.) is required. The water taking should not have unacceptable interference on soils and underground structures (foundations, utilities etc.).
- An agreement to discharge into the sewers owned by the City of Ottawa will be required prior to releasing dewatering effluent into the City owned sewers.
- A groundwater management plan (including water quality monitoring and mitigation methods) must be developed and be in effect during and in post-construction stage to monitor the discharge water quality if any discharges from the Site will be directed to the City sewers.;
- The daily water taking records must be maintained onsite for the entire construction dewatering period. The Discharge Plan, hydrogeological investigation report, and geotechnical assessment of settlements must always also be available at the construction Site for the entire construction dewatering.
- EXP should be notified immediately about any changes to the construction dewatering schedule or design, since EASR will need to be updated to reflect these modifications. The hydrogeological report, Groundwater Management Plan and geotechnical assessment constitutes the Water Taking Plan which needs to be available onsite for the duration of construction dewatering.

- In conformance with Regulation 903 of the Ontario Water Resources Act, the installation and eventual decommissioning of any dewatering system wells or monitoring wells must be completed by a licensed well contractor. This will be required for all wells that are no longer in use.

The following is recommended:

- An assessment related to geotechnical issues (consolidation and settlement of utilities and engineered structures nearby) as it pertains to the Site is required to be completed.

The conclusions and recommendations provided above should be reviewed in conjunction with the entirety of the report. They assume that the present design concept described throughout the report will proceed to construction. This report is solely intended for the construction and long-term dewatering assessments. Any changes to the design concept may result in a modification to the recommendations provided in this report.

8 Limitations

This report is based on a limited investigation designed to provide information to support an assessment of the current hydrogeological conditions within the study area. The conclusions and recommendations presented within this report reflect Site conditions existing at the time of the assessment. EXP must be contacted immediately, if any unforeseen Site conditions are experienced during construction activities. This will allow EXP to review the new findings and provide appropriate recommendations to allow the construction to proceed in a timely and cost-effective manner.

Our undertaking at EXP, therefore, is to perform our work within limits prescribed by our clients, with the usual thoroughness and competence of the geoscience/engineering profession. No other warranty or representation, either expressed or implied, is included or intended in this report.

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We trust that this information is satisfactory for your purposes. Should you have any questions or comments, please do not hesitate to contact this office.

Sincerely,

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9 References

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2. J.P. Powers, A.B. Corwin, P.C. Schmall and W.E. Kaeck (2007). Construction Dewatering and Groundwater Control, Third Edition.

Figures

Appendix A – MECP Water Well Records

Appendix B – Borehole Logs

Appendix C – SWRT Results

Appendix D – Results of Laboratory Analysis

Appendix E – Construction and Post-Construction Flow Rate Calculations